Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of

Promoting More Efficient Use of Spectrum Through Dynamic Spectrum Use Technologies	ET Docket No. 10-237

Via the ECFS

COMMENTS OF IEEE 802.18

IEEE 802.18, the Radio Regulatory Technical Advisory Group ("the RR-TAG") within IEEE 802[1] hereby submits its Comments in the above-captioned Proceeding. This document was prepared and approved by the RR-TAG, and also was reviewed by the IEEE 802 Executive Committee.[2]

The members of the RR-TAG that participate in the IEEE 802 standards process are interested parties in this proceeding. We appreciate the opportunity to provide these comments to the Commission.

INTRODUCTION

1. On November 20, 2010, the Commission released document FCC 10-198, a Notice of Inquiry ("NOI") titled "Promoting More Efficient Use of Spectrum Through Dynamic Spectrum Use Technologies".
2. In our response, the RR-TAG has incorporated inputs from subject matter experts within IEEE 802, specifically from the IEEE 802.11 Wireless Local Area Network Working Group ("802.11") and from the IEEE 802.22 Working Group on Wireless Regional Area Networks ("802.22").
3. The 802.22 membership comprises the entire ecosystem of interested parties such as TV broadcasters, service providers, chip manufacturers, device manufacturers, Department of Defence contractors, Govt. and non-Govt., academic institutions and universities. The 802.22 member

[1] The IEEE Local and Metropolitan Area Networks Standards Committee ("IEEE 802" or the "LMSC")
[2] This document represents the views of IEEE 802.18. It does not necessarily represent the views of the IEEE as a whole or the IEEE Standards Association as a whole.

organizations not only bring state of the art research to convert these technologies into products but also the knowledge on how to successfully develop and deploy these systems.

4. The IEEE 802.22 project on cognitive radio based Wireless Regional Area Networks ("WRAN") has three projects under its umbrella.
    a. The IEEE 802.22.1-2010 standard on enhanced protection of low power licensed devices using a beacon technology has been completed and was published in November 2010.
    b. The IEEE 802.22 standard, specifying the broadband wireless air-interface, is on-track to be completed in 2011.
    c. The IEEE 802.22.2 standard, a recommended practice for deployment of 802.22 systems, is being developed in parallel with the 802.22 standard.
5. For more overview information on the IEEE 802.22 Standard, please refer to our website at www.ieee802.org/22 (under the Core Technologies).
6. The 802.11 membership consists of technical experts from a variety of companies whose work has created the most widely deployed wireless local area network ("WLAN") standard in the world. Presently, 802.11 is engaged in created an amendment to the 802.11 standard, designated 802.11af, to address opportunities for WLAN network operation in the TV White Spaces ("TVWS") under Commission's the recently released TVWS rules.
7. The members of the RR-TAG, of 802.11, and of 802.22 appreciate this opportunity to provide inputs to the Commission's timely NOI focused on Dynamic Spectrum Access ("DSA") technologies.
8. In order to make our responses consistent with the NOI, we will refer to the clause and question we are responding to in the following paragraphs.

PARAGRAPH 18: INFORMATION ON THE CURRENT STATE OF THE ART IN DYNAMIC SPECTRUM ACCESS RADIOS

9. **Question: What is the current state of equipment and system development?**
10. While we don't actually develop equipment, over the last decade we have gained considerable knowledge of the technologies that are necessary to successfully develop standards for efficient usage of the spectrum using new technologies such as DSA, spectrum sensing, access to a database, beaconing, etc.
11. For example, the IEEE 802.22 project team (www.ieee802.org/22) has developed a PHY / MAC air interface to provide cognitive radio ("CR") and DSA based broadband wireless access in the TV White spaces. This project has been concurrent with the FCC's proceeding on unlicensed operation in the TV Whitespaces and the resulting proposed standard has optimized robustness and spectrum utilization in line with the requirements identified in the FCC proceeding.

12. We also point out that the 802.11 published standards include mechanisms which allow effective sharing in the 3650 MHz band and in the 5 GHz band.
13. **Question: What approaches have developers taken with respect to mitigating hidden nodes where shadowing may make it appear that the spectrum is unoccupied when in fact it is being used nearby? Which methods have met with the most success? What solutions are available for dynamic radio operations in the vicinity of (primarily) receive-only sites?**
14. We have recognized the challenge posed by the hidden node issues (e. g., protecting wireless microphones in the TV bands). In 802.11, the approach taken to date focuses on geolocation by means of a real time database. The standards development work in 802.22 is, in part, based on the view that spectrum sensing is more suitable than database registration to protect licensed and unlicensed wireless microphone usage due to the dynamic and unpredictable nature of on-location news and emergency reporting.
15. However, because of the fade margin allowed in the operation of the microphones, the detection range of the low-power signals is unacceptably shorter than the potential range of interference from a 4 W EIRP White Space Device ("WSD") as envisioned in the 802.22 standard. The 802.22 team has accounted for this difficulty by publishing the IEEE 802.22.1-2010 standard ("802.22.1") for enhanced protection of licensed low-power devices.
16. 802.22.1 specifies a beaconing system that indicates the presence in a channel of protected wireless microphones in an area. Systems based on the draft 802.22 standard detect and react to the IEEE 802.22.1 beacon and vacate the relevant spectrum. Our draft base standard uses a combination of cognitive techniques (e.g. spectrum sensing, database service and beacons) to protect the primary users and to avoid the hidden node issues.

PARAGRAPH 21: SPECTRUM SENSING TECHNOLOGIES

17. **What innovations to sensing are contemplated? Has there been any industry wide consensus regarding methods of implementing sensing? Have there been studies regarding which sensing methods work best among using matched filters, simple energy detection, or cyclostationary detection or other techniques? Are there ways to generalize sensing requirements, or do they need to be determined band-by-band based on the incumbent services? Advocates for band by band requirements should also address methods for updating sensing algorithms based on usage changes over time. How has filter technology advanced such that false positive detections due to adjacent channel signals can be minimized? Can a common standard for spectrum sensing be developed? What would need to be included in such a standard? How should the detection threshold for spectrum sensing be determined? How can dynamic spectrum access radios avoid adjacent channel interference to incumbent systems? Upon detection, should a**

minimum frequency offset be established to avoid adjacent channel interference? What factors impact detection time and how do they vary for different incumbent radio services (*e.g.*, land mobile systems versus radar systems)?

18. The 802.22 team investigated a variety of spectrum sensing techniques such as cyclostationary approaches, higher order statistics, covariance based approaches, matched filter, energy detection etc. to detect and recognize the signals of interest. The proposed standard has created a dedicated Annex that describes these techniques and provides detailed quantitative performance comparisons for various techniques using over-the-air captured signals that were provided to the various participants.
19. The 802.22 draft standard accommodates the use of spectrum sensing for deployment of WRAN systems. The draft standard recommends signal type determination in addition to basic signal detection in order to protect against cognitive attacks, for example, primary user emulation and spoofing.
20. In cases where signals are well above the noise floor, simple techniques such as energy detection and interference detection, i.e., correlation in the rise of the noise floor, may be used.
21. In general we believe that no one technique is sufficient to accurately detect and characterize the signals *with reasonable computational complexity* and for all types of signals.
22. For example, cyclostationary and higher order statistics based approaches are suitable to detect and characterize a wide variety of signals at low Signal to Noise Ratios ("SNR"). However, they suffer from relatively high computational complexity.
23. 802.22 investigated techniques that would allow detection of signals some 20 dB below the noise floor. For this case, the use of a combination of techniques, such as energy (interference) detection, Receiver Signal Strength Indication ("RSSI") monitoring, and more complex feature based techniques, may be needed to detect and identify the signal.
24. We continue to believe that spectrum sensing will play an important role in DSA systems. However, additional mechanisms will be required if determining the protection criterion of a detected signal is necessary.
25. Member companies of 802.22 are working with Government agencies such as DARPA to continue pursuing advancements in spectrum sensing technologies.

PARAGRAPH 29: POLICY RADIOS

26. **Questions: How should policies be developed for these dynamic radios? Who should be responsible for developing these policies? Should the policies be incorporated as part of individual service rules? What is the appropriate hierarchy among the Federal Government, industry, and users of policy radios? If policies are developed by non-governmental entities,**

should the Commission or other appropriate agencies have the option to review or modify policies before they become effective? What factors should be considered in developing dynamic radio policies? How often should policies be reviewed for possible modification? How do we ensure that dynamic policies are distributed to all devices in a timely manner? What procedures can be used to ensure the distributed polices are implemented properly?

27. 802.22 has devoted significant effort towards addressing the issues of enforcing the policies in Cognitive Radios. While developing the policies for the radios, the Working Group considered aspects such as how to ensure policy enforcement and security, minor differences in policies proposed by various regulatory domains, etc.
28. 802.22 currently uses rule-based policies specific to the bands in which these system are designed to operate. The policy framework has been made generic enough to allow its operation in various regulatory domains.
29. The policies are driven by certain regulatory dependent parameters (e.g. Channel Move Time, Database Refresh Time, etc.) which are pre-configured by the manufacturer before coming on the market to ensure appropriate operation in the given regulatory domain.
30. An integrated cognitive engine called the "Spectrum Manager" has been defined within the 802.22 draft standard that is responsible for enforcing the policies of the given regulatory domain. The Spectrum Manager is also responsible for accessing, processing and executing other cognitive inputs and functions such as database service, sensing etc.

PARAGRAPH 38: SECONDARY MARKET MECHANISMS - TIME, FREQUENCY AND SPATIAL APPROACH FOR INTERFERENCE MANAGEMENT AND SPECTRUM SHARING

31. We support the Commission's position that effective spectrum sharing and interference management may require the use of all the measurable dimensions (e.g., frequency, time, spatial, geographic, etc.).

PARAGRAPH 48: REAL-TIME DATABASE SERVICE

32. **Question: We seek comment on whether such an approach (use of real time database service) would also work in fixed microwave bands. How might such an approach be instituted in these bands? Should the Commission consider promoting such an approach, and if so, how? Are there other candidate bands? How would a real-time database be maintained so that it contains up-to-date information? Similarly, we seek comment on whether and how such an approach would work in highly mobile bands.**

33. Although the real-time database service approach is suitable for the TV bands, we recommend the following approach:

    a. **The Access model** of the TV bands database needs to be defined, developed and fully tested before extending this model to other services.

    b. **Push technologies** such as those used for synchronous audio and video conferencing as well as instant messaging have been successfully developed and are widely used today. Push technology needs to be considered for DSA systems where the spectrum usage patterns are likely to change more rapidly. Push technology will also reduce the amount of Internet traffic, since the database service provider can selectively send messages to the interested parties in case changes to transmit characteristics (e. g. frequency, power etc.) of the devices are needed, rather than the devices continuously querying the database.

    c. **Security aspects and database access** need to be taken into account. Entities that are present on the Internet are susceptible to various kinds of Denial of Service ("DoS"), cyber attacks, and related information assurance issues. The level of effort required to stage such attacks are low and the risk of system failure is very high. Another issue of manual entry database is that of trust. Adequate considerations need to be made to establish a secure connection between the DSA device and the database service. Security aspects such as authorization to access, authentication, identification, data integrity, non-repudiation, confidentiality and privacy need to be considered.

34. We believe the real time database approach provides a scalable solution.
35. We further believe that establishing geographic location is ever less expensive, in ever more circumstances.
36. The interest of most of our members is not in exclusively licensed spectrum, rather it is in shared use spectrum, for which a robust geolocation database as described above is a reliable solution.
37. Based on the work already done in 802.11, we have demonstrated response times well under one minute in commercially available equipment based on the published 802.11 standard and amendments. Going forward, we expect to be ever more timely and securely responsive to other authorized spectrum users.

PARAGRAPH 50: REAL-TIME SPECTRUM MONITORING

38. **Questions: Generally, we seek comment on whether such a system of monitoring equipment could be deployed at a reasonable cost. Should such a network be administered by the U.S. Government or the private sector? If the private sector, how should the collected information**

be disseminated? For example, should a fee be charged? Could a low-cost sensor be developed to effectively detect the presence of weak radio signals? How would a system of sensors perform in urban areas or in areas where there is irregular terrain?

39. The development of a countrywide network of distributed sensors that monitors the spectrum and reports any unauthorized signals to the FCC official database for further investigation could be beneficial to complement other techniques of interference avoidance such as use of databases and beacons. It may also help to act as a sentry on the ground to corroborate the information that has been provided to the database service. This technology may help to make the proposed DSA network more robust. For example, 802.22 has incorporated distributed sensing features into the standard to complement the interference avoidance techniques and enhance security.

CONCLUSION

40. 802.18 appreciates this opportunity to provide information on IEEE 802 projects related to dynamic spectrum use. As these standards are deployed and implementation experience is gained, we believe the utility of shared spectrum operations will stand the test of time.

Respectfully submitted,

/s/

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